HCl from EOS MLS on Aura: version 1.5 and preliminary version 2 data comparisons

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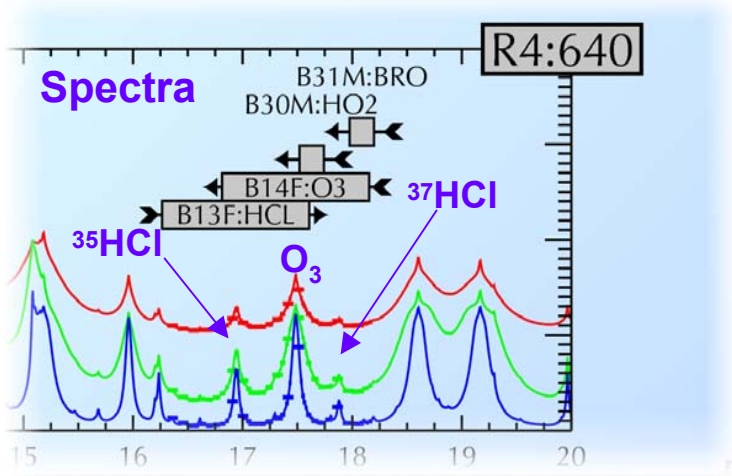
satellite and balloon data teams

MLS provisional version 2.1 data: HCl

- **Changes from version 1.5**
  - Starting in February 2006, signs of aging seen in primary 640 GHz HCl band (B13)
  - Thought due to radiation hardness issues in a particular batch of transistors
  - B13 off since Feb. 16; plan to turn it on infrequently as consistency check (1 day at a time, on occasion)
  - HCl now comes from adjacent band (B14) covering most of ^{35}HCl line and isotopic ^{37}HCl line



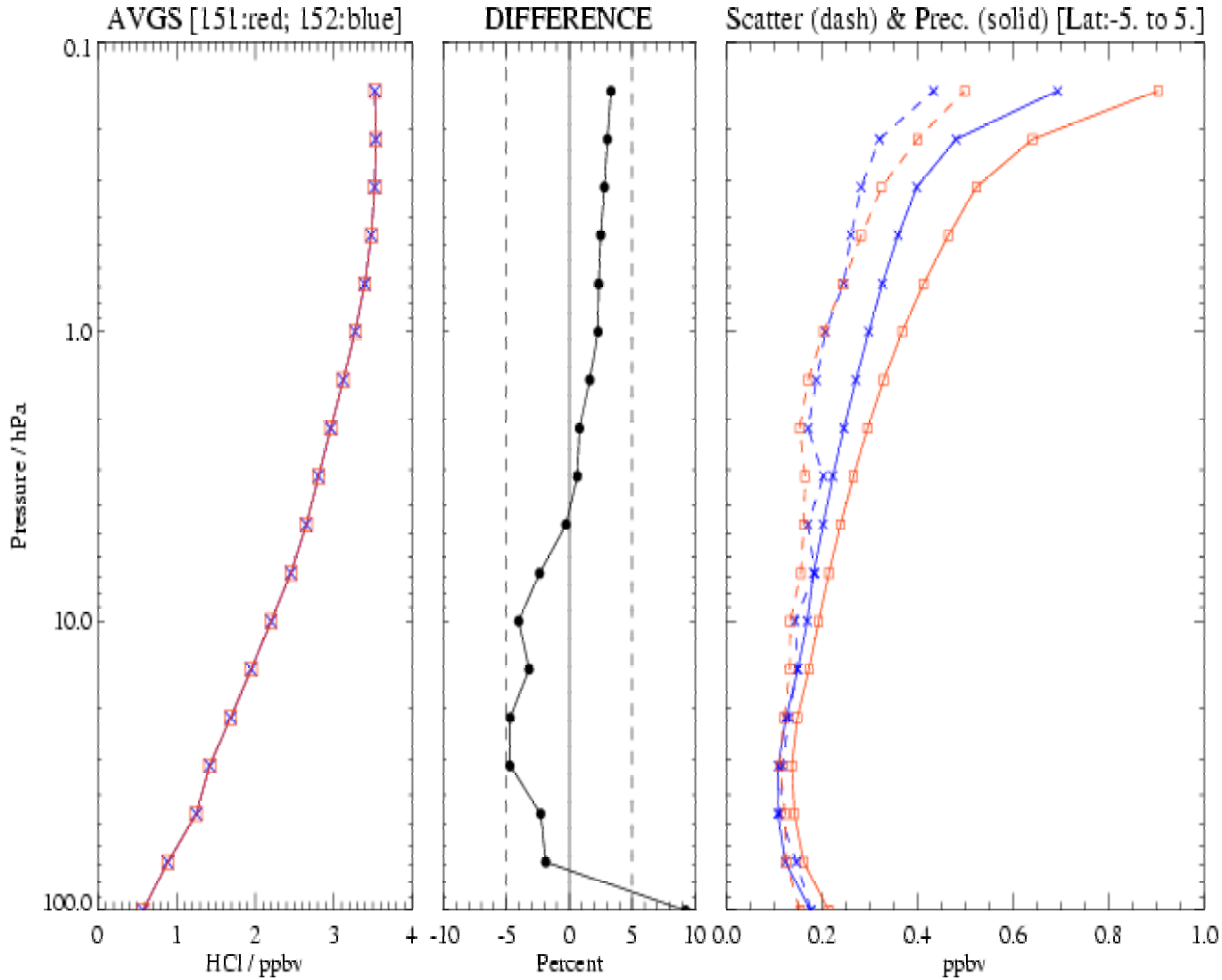
→ Version 1.52 has small systematic difference (a few % in upper strat.) versus V1.51
+ somewhat poorer precision (by ~30%) and poorer vert. resolution

- **Version 2.1 has some other changes**
  - Spectroscopy: not for HCl directly, but small linewidth changes to O_3 (640 GHz) lines
  - Changes in treatment of retrievals for temperature and tangent pressure
    > Different bands/channels & calib. adjustments → a few K cooler & changes in P_{tan} (~ 300m near 1 hPa)
    > Halve the retrieval's vertical grid spacing (from 6 coefficients/decade in P to 12/decade - for P> 21 hPa)
  - Changes in the treatment of vertical smoothing constraint
    > Less constraint → better (~ 4 km) vertical resolution in upper stratosphere (but noisier)

- **Changes in the retrieved standard HCl product (V2.1 versus V1.51)**
  - Precision (and observed scatter) are degraded (by ~factor of two)
  - Systematic changes: < 5% for upper stratosphere, ~10 % for lower stratosphere
  - However, MLS HCl at 147 hPa still not deemed reliable enough (e.g., negative biases)

Changes in HCl from v1.51 to v1.52 (after Feb. 16, 2006)

- Small (but non-negligible) changes occurred when switching to Band 14 from Band 13
  - Band 13 was turned off on Feb. 16, 2006 because of a rapid degradation in counts (after Jan. 2006)



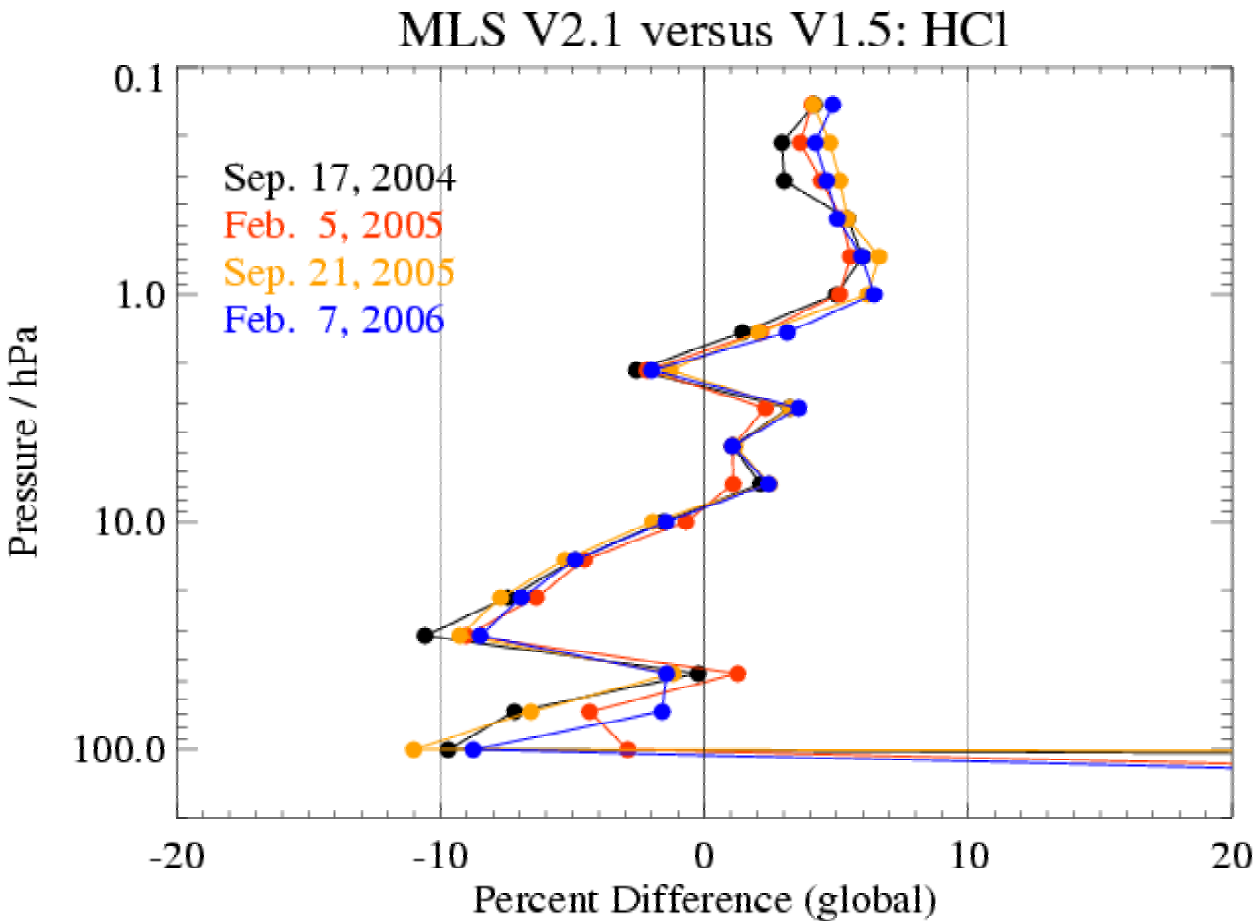
Global differences using v1.52 versus v1.51 retrievals (for Feb. 14, 2006)

v1.52 values are:

- 2 to 3% larger in upper strat. & lower mesosphere
- 3 to 5 % smaller in lower strat. (except for 100 hPa, where values are ~10% larger than v1.51)

Est. precision for v1.52 retrieval is poorer by 30-40% in upper stratosphere

MLS provisional version 2.1 data: HCl

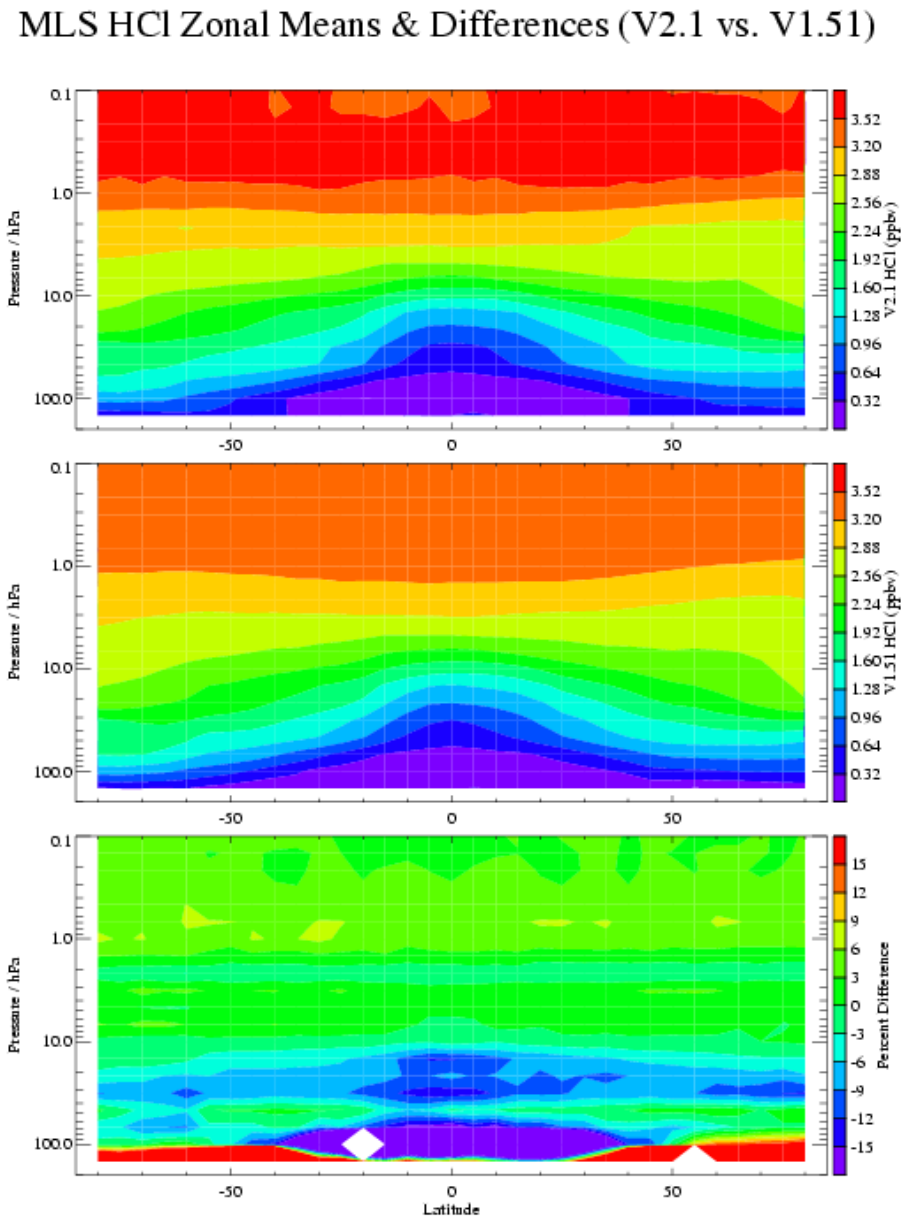


HCl differences (global averages) from v1.51 to v2.1 are quite reproducible from day to day and over more than 1 year

- based on a few days that have been reprocessed with v2.1

Note: because of the increased noise for single profiles (mainly in upper strat.), detection of small (5%) differences requires averaging of a number of profiles

MLS provisional version 2.1 data versus version 1.5 data: HCl



- Based on 17 days of v2.1 MLS data (made available on the AVDC)

The HCl differences (V2.1 – V1.5) are fairly constant with latitude

- mean values in tropics near 100 hPa are closer to zero, probably a good thing (given very low values expected and observed during CR-AVE)

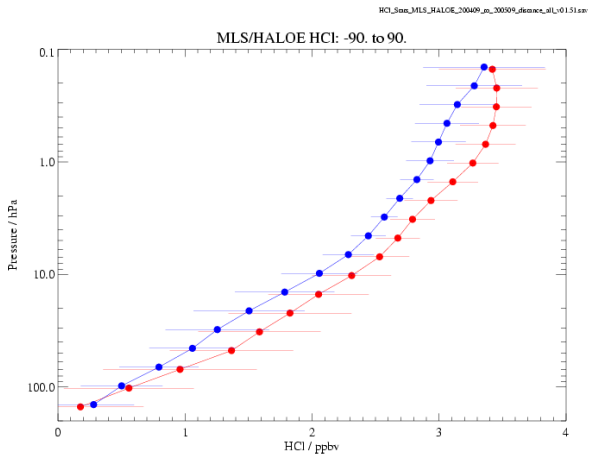
MLS HCl: brief review of status for v1.5 data

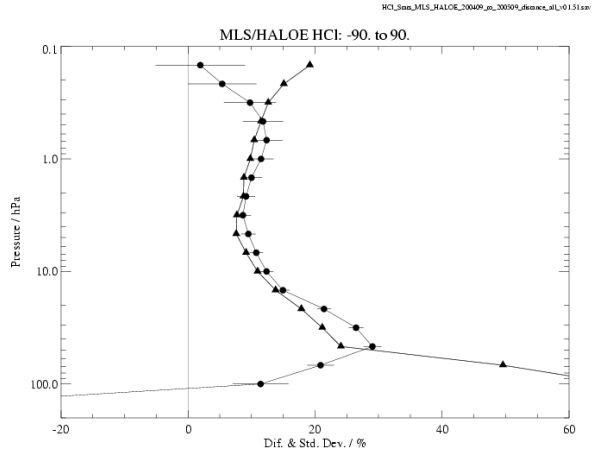
see *Froidevaux et al., 2006* IEEE paper + Sep. 2005 Aura validation meeting

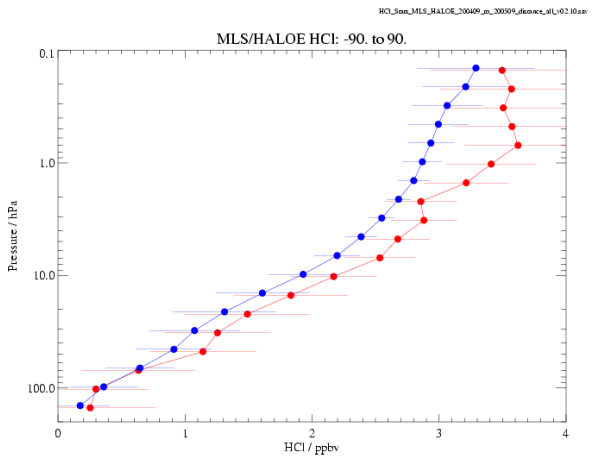
- MLS v1.5 HCl has ~10 -15% positive bias versus HALOE
  - but HALOE values > other correlative data (ATMOS, balloon data) by a similar amount
- MLS v1.5 HCl within ~ 5% of ACE-FTS values
- Good tracking versus latitude (MLS vs HALOE and ACE)
- Some differences in temporal changes (monthly means), MLS vs HALOE; not obvious why, although sampling explains some of this.

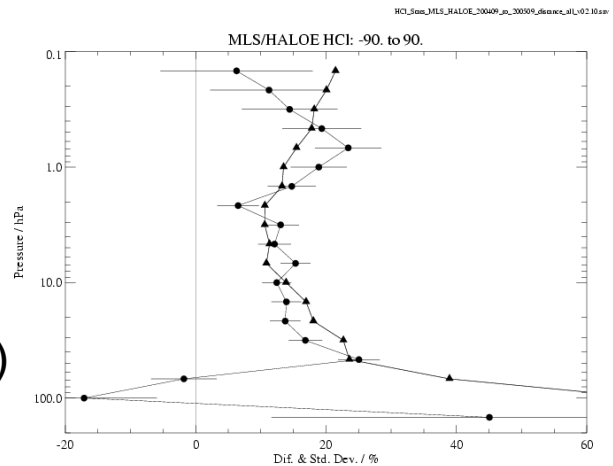
Changes to MLS HCl in v2.1: impact on comparisons

Satellite Data: MLS and HALOE HCl comparisons









MLS vs HALOE (V19)
coincident matches
based on 17 days

Top: MLS V1.5 data

Bottom: MLS V2.1 data

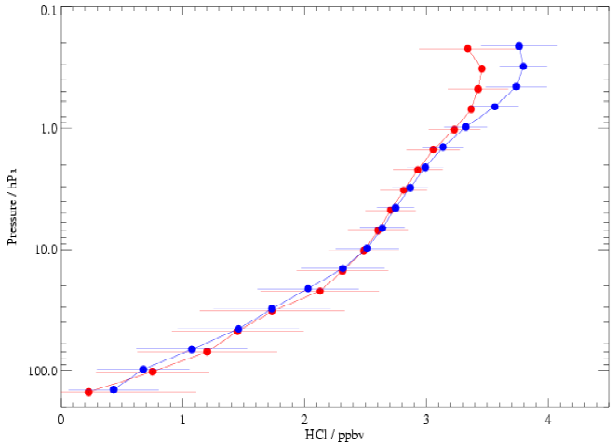
Left panels: average profiles (global)

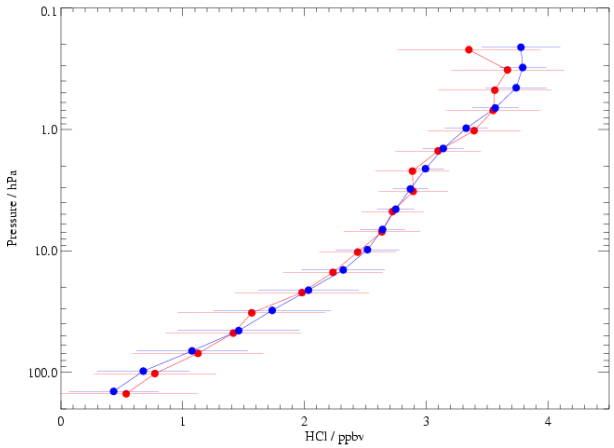
Right panels:
dots: avg. difs. (+ prec.)
triangles: std. devs.

MLS/HALOE comparisons are not changed significantly, overall, compared to the systematic differences of ~10-15% (as expected from changes between V1.5 to V2.1)

Changes to MLS HCl in v2.1: impact on comparisons

Satellite Data: MLS and ACE HCl comparisons





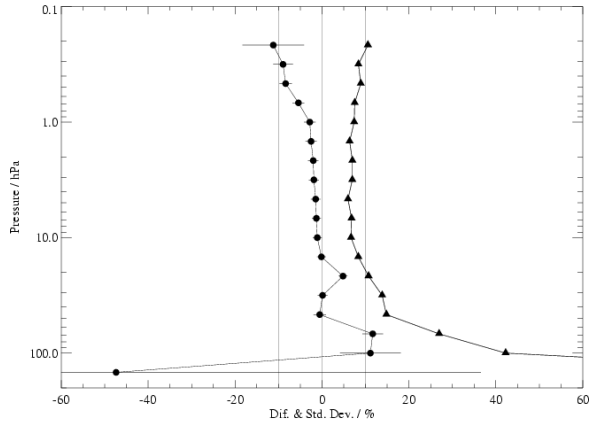
MLS vs ACE (V2.2)
coincident matches
based on 17 days

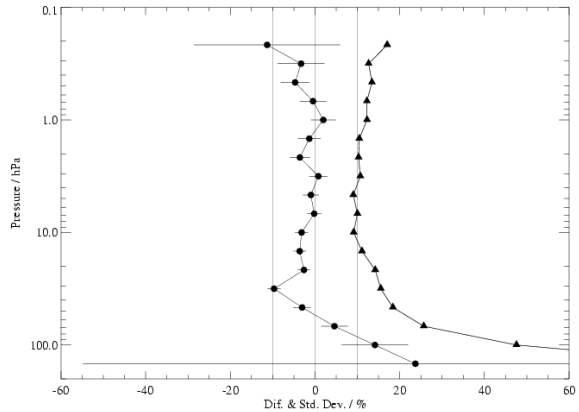
Top: MLS V1.5 data

Bottom: MLS V2.1 data

Left panels: average profiles (global)

Right panels:
dots: avg. difs. (+ prec.)
triangles: std. devs.





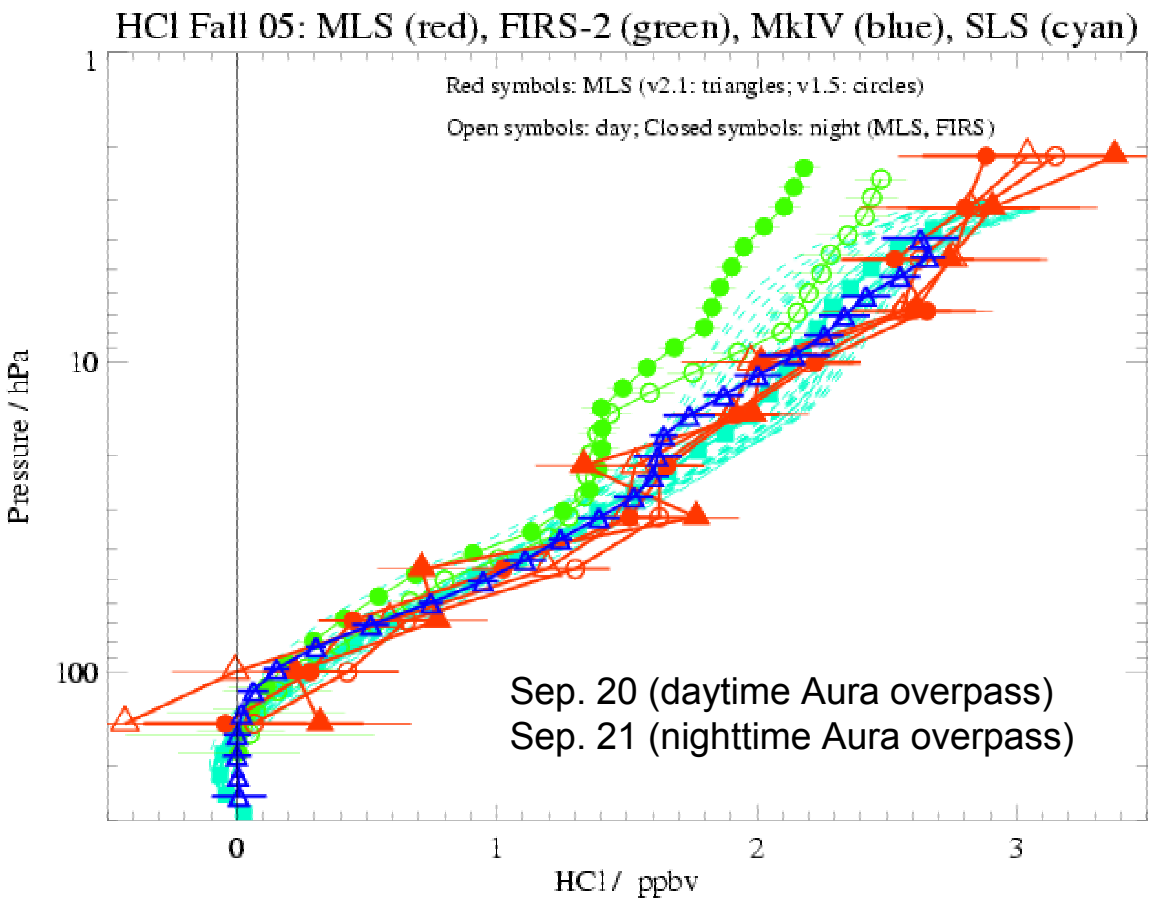
MLS/ACE comparisons (from a few days of data) still show good agreement
- Now seem to obtain better agreement with ACE profiles in lower mes. (up to 0.3 hPa)
- More days/statistics will give more robust results + can check diffs. vs latitude

Changes to MLS HCl in v2.1: impact on comparisons

Balloon Data

Changing HCl by ~ 5% will not result in an easily discernible change to a few balloon profile comparisons

- differences between balloon datasets can be > 5%
- accuracy and single-profile precision for balloon and MLS datasets also > 5%



Compare MLS versus balloon HCl data
(Fall 2005, Ft. Sumner)

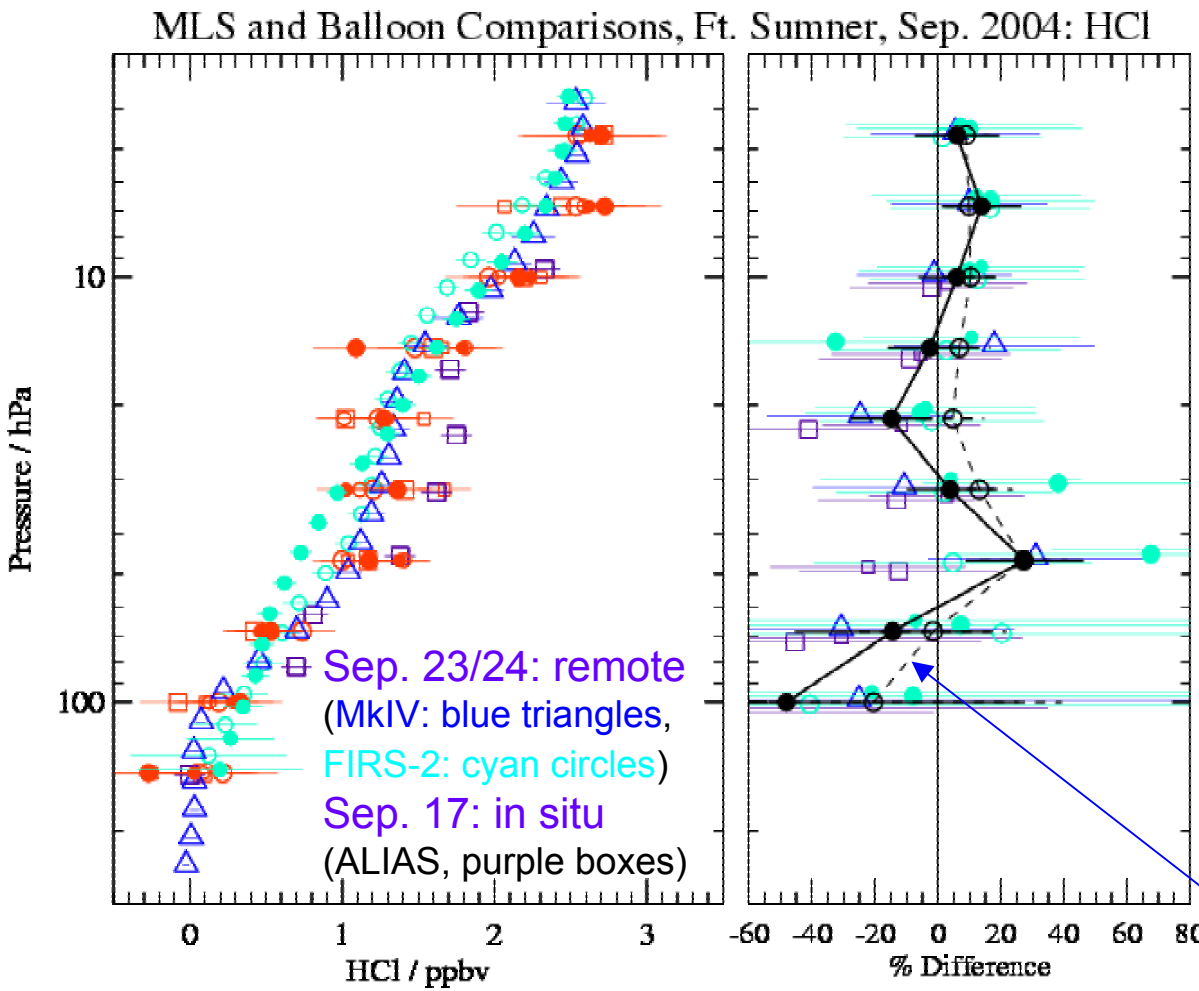
- Both data versions for MLS agree well with MkIV and SLS (avg.) profiles

- Some of the currently archived (but not final) FIRS-2 profiles give significantly lower HCl values, in particular for Sep. 21 (night) and P < 10-20 hPa, compared to the other profiles

- at least partly explainable by profile shape assumptions and other factors (balloon sinking at night),… [per K. Jucks]

Changes to MLS HCl in v2.1: impact on comparisons

Balloon Data: September 2004, Ft. Sumner



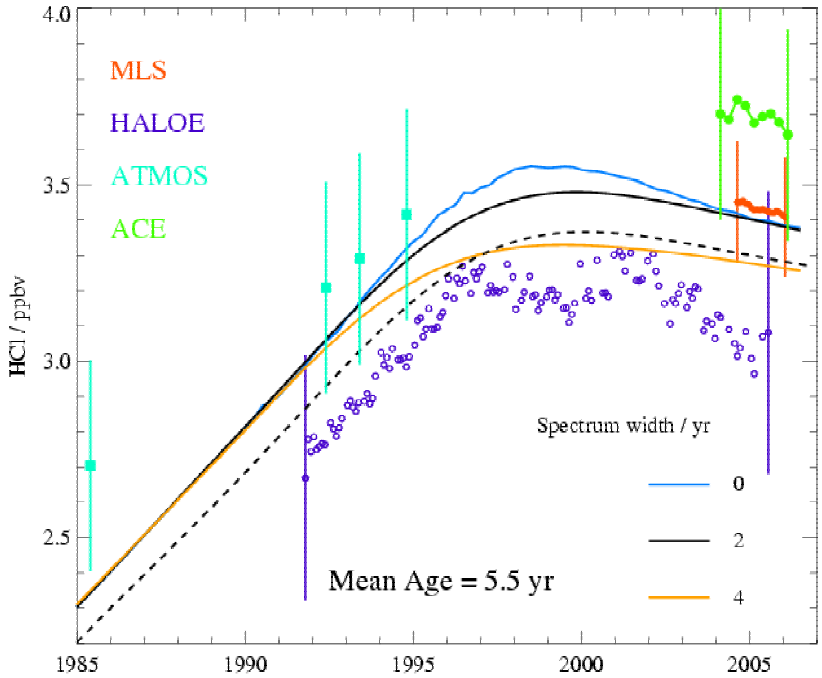
The average results for 2004 versus the balloon data show agreement to within 10-15% with MLS v2.1 data for 32 to 4.6 hPa, with larger variations at higher pressures.

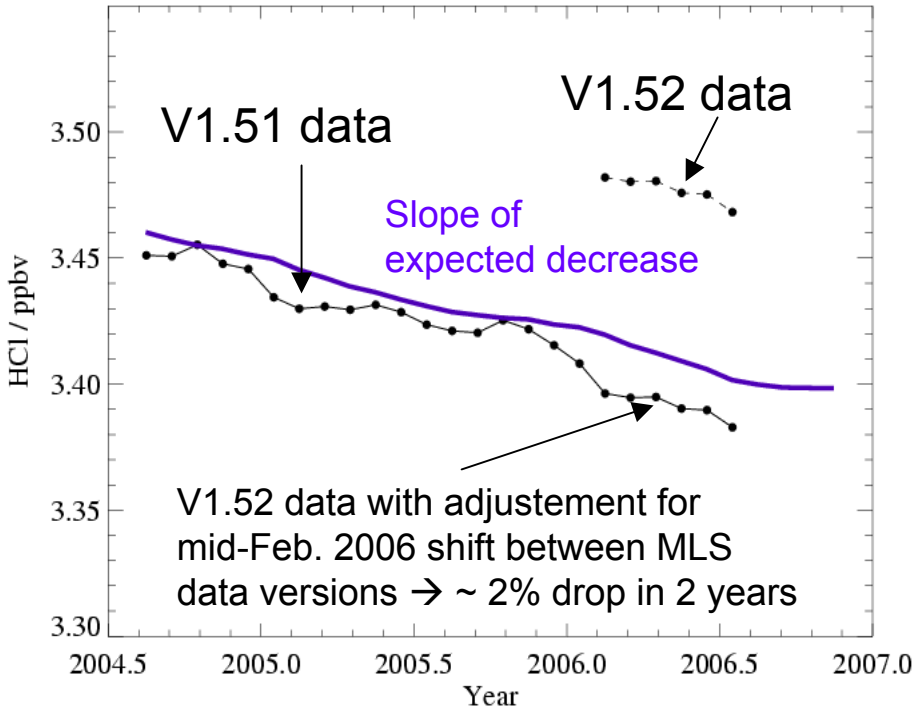
Several more flights would probably be needed to discern any clear biases (if such biases exist) between these datasets

- also, cannot get reliable results (or extrapolation) for the uppermost stratosphere, most relevant to total chlorine

MLS v2.1 results shown here (but dashed avg. in right panel is for MLS v1.5 data)

Temporal changes in HCl (monthly near-global means) [~ 0.5 hPa, ~ 53 km]





Abundances and decreases in HCl are as measured above for HALOE, MLS, ACE.

- MLS frequent and repeatable coverage → a few pptv precision for 10° zonal means and decrease of ~ - 0.8% per year for first 18 months

> agrees with expectations from in situ ground data on total trop. chlorine (for ~5.5 yr time lag and ~0-2 year age spectrum)

Can add V1.52 monthly means cautiously after adjustment for small (but non-negligible vs yearly decrease) shifts between v1.51 and v1.52 data.

- Global decrease continues.
- **Note: Will need to reprocess the whole MLS mission (since Aug. 2004) to get best/consistent time series for analyses across Feb. 2006 time period.**

Summary and plans: MLS HCl validation

- **Validation comparisons are continuing – and within < 5-10% of v1.51 results**
  - v1.52 for Feb. 16, 2006 and onward; use different band/channels (+ isotopic HCl line)
  - v2.1 (and planned v2.2) retrievals also differ some (T, P_{tan}, and spectroscopy for nearby O_3 lines) + noisier (less smoothing constraint → better vertical resol. in upper stratosphere)

    MLS HCl still > HALOE; < ~5% diff. vs ACE-FTS for most of 68 hPa - 0.5 hPa [17 days only]
- **Validation paper for special issue**
  - *L. Froidevaux et al.* manuscript planned on HCl validation
    - > Plan to mainly use v2.2 MLS data
    - > Expand on satellite comparisons shown here; separate vs latitude and time of year, update HALOE and ACE results (possibly use v1.5 data for some time series info.)
    - > Add detailed error analysis (already done for upper stratosphere)
    - > Include results/updates from balloon campaigns (Ft. Sumner 2004, 2005, - 2007??)
    - > Add something on AVE, CR-AVE results

      (although nothing new on aircraft results shown here); to be discussed with CIMS team.
  - Other related validation manuscript plans?

    > Please contact L.F. if wish to coordinate and to avoid duplication (+ as a courtesy).
- **Validation needs?**
  - Campaigns: check high latitude winter balloon data (Kiruna 2007) for different conditions in the lower stratosphere (depleted HCl), although 'one snapshot' is not a stringent constraint
- **Longer-term planning (mostly)**
  - Continue to look at MLS upper stratospheric data versus expected decreases
  - Continue consistency checks between MLS & ACE-FTS + more balloon data (08, 09?)
  - Add comparison to column IR data ($HCl+ClONO_2$) [for > 2-3 yrs of MLS V2 data] + MW ClO